Real-World Issues and Applications for Real-time Geographic Information Systems (RT-GIS)

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What Is Real-time?

"The performance of a computation during the actual time that the related physical process transpires, in order that results of the computation can be used in guiding the process."[1]

[1] IEEE, *Software Engineering Standards*, 3rd ed., 1990

Application Dependence

Key Functions of Real-Time Geographic Information Systems

- Manages spatial reference to data
- Provides continued access to database throughout query, retrieval, analysis, and information use
- Analysis functions are responsive enough to support a real-time process
- Overlays of vector and raster data
- Topological relationships are maintained

NRL's Primary RT-GIS Customer

- Naval Oceanographic Office,
  Applied Hydrography Division N54
  - T-AGS 60 survey ships
  - Integrated survey system ISS-60
  - Increasing data volumes
  - Decrease in personnel
  - Currently using flat file management schema

NAVO N54 Needs

- Support for several standard data formats
- Support for ever increasing data volumes
- Object-oriented data model
- Dynamically reconfigurable surveying
- GIS functionality to analyze data in-situ
- Use of commercial off-the-shelf (COTS) software

Definition of Real-time

$$\mathbf{RT} = (1 / \mathbf{M}) \left[\mathbf{DI}(d_1, \ldots, d_i) + \mathbf{TP}(t_1, \ldots, t_j) + \mathbf{GIS}(f_1, \ldots, f_k) + \mathbf{OV} \right]$$

where

DI = data ingestion time
TP = database transaction processing time
GIS = spatial analysis/display function time
OV = system overhead
M = coefficient (money spent for bettering system)

NRL Approach to RT-GIS

- Use COTS CORBA compliant tools
- Develop an Object-Oriented Data Model
- Maintain access to common COTS GIS
- Adopt Geospatial Information DataBase (GIDB) Framework
- Add GIS functionality to analyze data in-situ to the GIDB tools
- Incorporate data translators for GSF, DIGEST, and S57 into GIDB

Geospatial Information Database (GIDB) Framework

- Object-oriented
- COTS components (GemStone®)
- CORBA-compliant
  - Common Object Request Broker Architecture
  - Internet access across diverse platforms
- Spatially referenced
  - Some GIS analysis and display functionality

Benefits of OO Design and Database

- Code reuse through inheritance
- Representation of complex data structures
- Encapsulation
  - Data and methods are stored together
  - Easier to modify or extend system
- Shorter development time
- Fewer errors

COTS Issues

- Low initial cost
- Interoperability
- Flexibility
- Reduce risks of schedule and budget overrun
- Must integrate with existing hardware and software
- Must analyze integrity and security risks

OO-Based Real-Time GIS Using GIDB Framework

In-Situ Survey Ops

Multi-Sensors Data Output

Real-Time GIS Based on GIDB Framework

Spatial Analysis Functions

Land Based RT-GIS Interface

Generic Sensor Format

GSF-Raw Sensor Data Stored At Sea in File System Structure

CORBA Broker for USER INTERFACES

IDL Specifications

Data Integrators

On Land - Post Processing & Data Storage Systems

BHPP

Warehouse Historical Data

GemStone OO-DBMS

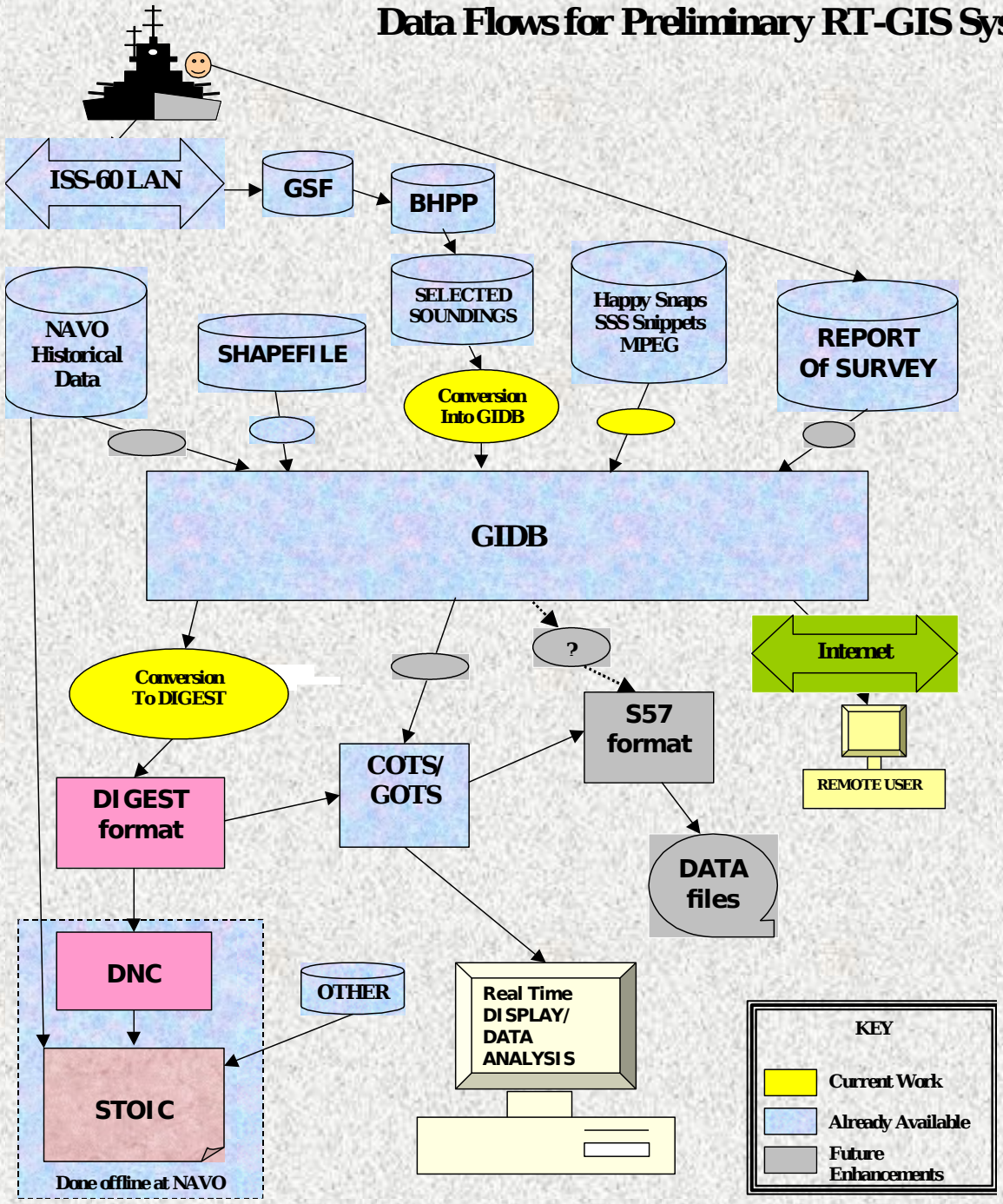
Topology

Geometry

Attributes

Ship Board LAN or Intranet

Data Flows for Preliminary RT-GIS System Design

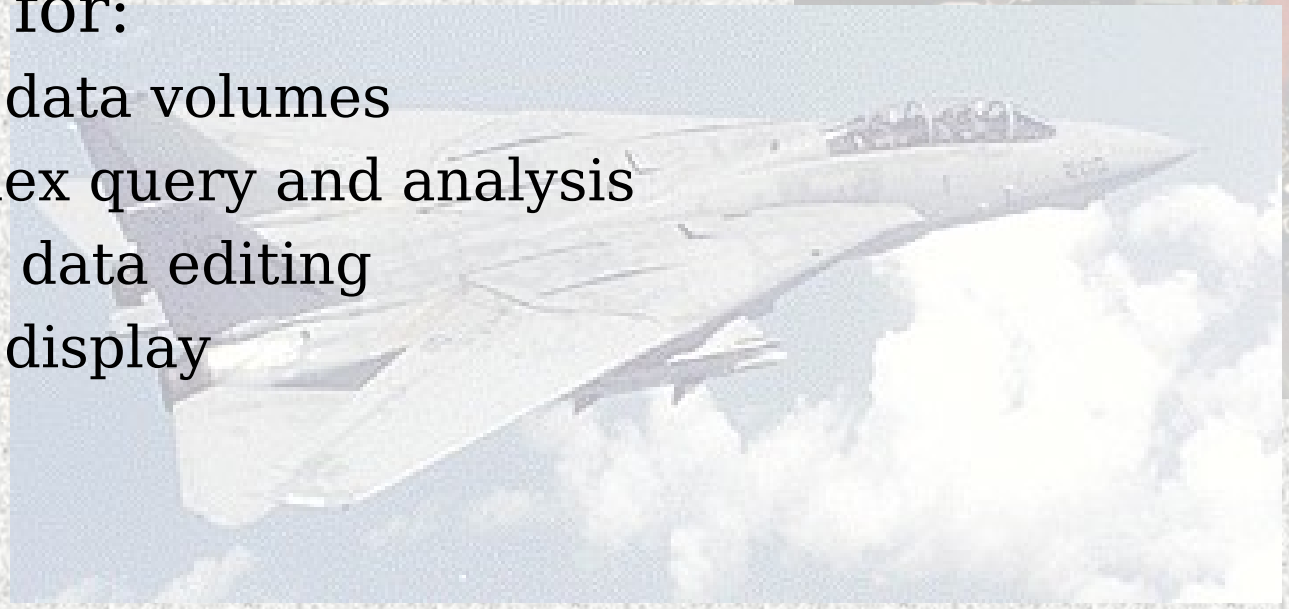


Considerations for Vector Moving Map Displays

- RT-GIS needs to be integrated into real-time processes:
  - Navigation/Precise Positioning
  - Intelligence gathering
  - Mission planning
  - Improving situational awareness
  - Targetting
  - C4I

Impacts on RT-GIS for Vector Moving Map Displays

- Choice of data paradigm impacts
  - Data performance and responsiveness
  - Ability to add analysis functions
  - Follow-on system design process
- System costs increase proportionally to user needs for:
  - Large data volumes
  - Complex query and analysis
  - In-situ data editing
  - Rapid display



RT GIS Requirements for Vector Moving Map Displays

- Maintain previously identified performance criteria
  - Display update/refresh rates
  - Switch map modes/scale changes
  - Quick reference to aircraft position
- Add new functionality unique to GIS:
  - Analysis functions on an active database
  - Complex query and change of area of interest
  - In-situ data editing using onboard sensors
  - Rapid display with query capability

Significant Influences on RT-GIS for Vector Moving Map Display

- Rate collection platform is capable of gathering and ingesting data
- Rate the user can receive and interpret data
- Rate of update required to maintain effective use of data

Photo Copied from http://pma205.navair.navy.mil/products/index.cfm

Conclusion

- Navy is steaming ahead to define real-time issues and impacts
- RT-Issues are very application dependent
- RT-GIS useful for Hydrographic Survey applications
- Hopeful that Real-Time issues can be quantified
- Vector Moving Map Display needs additional consideration as to real-time component